were imported from Australia—and more cheaply than they could be hewed from the resistant tropical woods close at hand. Trains now run regularly from the terminal stations three times a week and take two days to cover the distance. The maximum speed allowed is from 15 to 20 miles an hour. There is wireless connection with Manaos, 500 miles away straight through the forest, and an ice plant and a water system have been in use for some time. More than twenty-five thousand workmen have been employed since work was begun. The mortality among them dropped from 125 per thousand in 1909 to 70 per thousand in 1912.*

Thus in the heart of a river system long closed by imperial edict we have a railroad, a wireless service, a telegraph line, steam launches, a pier for ocean-going steamships, and a great commercial future. The mystery of the Amazon basin diminishes. The recent difficulty between Brazil and Bolivia only serves to emphasize the real reason for the long-delayed development. The irritating exclusiveness of Brazil was not due to the acceptance by old Dom Pedro of medieval standards, as many have supposed, but to a desire to avoid costly boundary disputes and the burden of policing a vast territory long so inaccessible except by "the flowing road" as to make by-words of law and order.

* Valley of the River Amazon—the Madeira-Mamoré Railway Co. By Albert Hale. *Bull. Pan-Amer. Union*, Dec., 1912, pp. 1116–1141. For descriptive articles on the history and construction of the Madeira-Mamoré Railroad, see *idem*, Jan., 1910; March, 1911; and Nov., 1911.

SOIL FLOW

The Berlin Geographical Society has done wisely in preparing this symposium* upon the subject of soil flow, which has only recently come prominently to the notice of geologists and geographers. The various processes to which the name soil flow (*solifluction* of Andersson) has been applied, would appear to be characteristic of sub-polar lands where the surface of the ground is in part snow covered and soaked with thaw water for a considerable season, as well as in those higher lying areas of lower latitudes within which essentially the same conditions prevail. This symposium has come about directly as a result of the International Geological Congress of 1910, which for the first time brought together a large body of geologists in a sub-polar region; though it should be

* A. Miethe, Ueber Karreebodenformen auf Spitzbergen; A. Penck, Ueber Polygonboden in Spitzbergen; H. Spethmann, Ueber Bodenbewegungen auf Island; G. Braun, Ueber Bodenbewegungen in Mittel und Südeuropa; Wilh. Meinardus, Beobachtungen über Detritussortierung und Strukturboden auf Spitzbergen; K. Sapper, Ueber Fliesserde und Strukturboden auf Spitzbergen: *Zeitschr. der Gesell. für Erdkunde zu Berlin*, 1912, No. 4, pp. 241–270, 2 pls.

pointed out that Swedish geologists and botanists had already given much attention to the subject, with which the names of Andersson, Nordenskiöld, and Högbom are especially associated.

Of the several contributors to the discussion, Professor Penck devotes his attention to the more common polygonal structures generally referred to under the name *Karreeboden*, which may perhaps be best rendered in English by barrow ground, the round form of dirt barrow supplying the illustration. Such structures are always found on flat areas, the surface being divided up into contiguous polygonal patches from one to two yards in diameter, marked out by zones of rock fragments often set on edge like the flat stones in a gutter pavement. A variation is, however, supplied by the absence of rock fragments, their place being taken by a raised ridge (bolster) of vegetation.

Though the geologists on the excursion were not of one mind concerning the origin of these structures, the discussion developed a unanimity in so far as to regard them as in all cases connected with the alternate freezing and thawing of surface layers of the ground more or less thoroughly saturated with water.

Thawing implies a contraction, and except for the larger areas of the resulting polygons this may be compared with the repeating polygons which are produced by the desiccation of mud. The expulsion from the interiors of the polygons of the enclosed rock fragments and their erection on edge within the marginal fissure involve processes less easily explained. Penck's view is that the clay ground mass of the material sucks in the water, which by freezing develops a pressure that forces the fragments to the surface, where a subsequent refreezing lifts them on low ice pedestals of the slightly domed surface of the polygon. From these positions they eventually slide off radially into the marginal fissure. In case such fragments are not included in the local terrain, the marginal fissure offers a foothold for the scant sub-arctic vegetation and a raised bolster ring is the result. The reviewer would suggest that the as yet little accounted but important wind-borne sand and dust of the sub-polar regions may play a large rôle in this latter process.

It is a much less common structure connected with soil flow which is discussed by Miethe, but one that is developed in remarkable perfection in Spitzbergen, close to the water's edge. On the gentle incline outside an abandoned shore line the structure appears at the surface as circular on slightly elliptical wreaths of rock fragements either alone, grouped, or closely crowded together, the diameter of the rings being generally some six to eight feet and the thickness perhaps a fifth of this amount. The rock fragments of the rings or wreaths average the size of the fist, whereas the area within is clay nearly free from stones and slightly domed. The rock wreaths, which usually project a foot or more above the general surface, were found by digging to descend some two feet or more into the tundra soil, and below this depth as well as without the wreaths, the rock fragments are distributed with uniformity throughout the clay. It was perhaps significant that the base of the structure was a particularly moist clay layer. Upon the surface the interiors and the margins of the wreaths are moss-grown.

Miethe's explanation of these structures assumes that when the snow is melting the otherwise frozen ground becomes thawed to the depth of the later developed structures, and the stream of ground water flowing under pressure in

the direction of the slope utilizes the frost cracks to rise loaded with mud to the surface where it overflows into the central area. The rock fragments are moved to the cracks but, as they do not rise, remain there, and as the interior areas settle down they are left in relief. An inner margin of mud within the stone crowns, was in some cases observed.

Meinardus after treating the common Karreeboden discusses further the stone wreaths which formed the subject of Miethe's studies, taking exception to the latter's explanation on the ground that the assumed stream of ground water which gives rise to the mud exudations at the surface cannot exist. He claims that at the depth of a half meter only, the ground temperature is late in June below o°C, though the supply of thaw water which must nourish the stream is then largely exhausted. In the main, his contribution to the discussion consists of a long and labored analysis and classification of the processes and elementary structures supposed to be involved in soil flow, which adds little to our knowledge of the subject but tends rather toward a confusion of ideas.

Spethmann discusses Icelandic variations of the process, three of which are of special interest. What he has designated "earth-rents" (*Erdreissen*), occur on flat areas and are cracks of a finger's breadth and a few centimeters depth which in either straight or but slightly curving courses run for many hundred yards without observable order, often intersecting to produce irregular polygons with average diameter of fifty to one hundred yards. Such cracks were once actually observed by Spethmann in process of formation during the night when the temperature was —2°C. Of slope effects of soil flow he describes mountains surrounded at the base by a ring or collar so as strongly to resemble volcanoes enclosed in "Somma" rings.

Another phenomenon is connected with plant colonies, which the Swedish geologists have long realized play a large rôle in soil flow. On some slopes the vegetal cover is scattered in patches ordered in lines so that differential soil flow yields hundreds of low hillocks known as "Thufa" to the Icelandic farmers. Such mounds constituting a serious hindrance to cultivation, they are often leveled by the farmers only to return after a few years.

Without special success, Braun has sought to correlate closely the well-known "creep" characteristic of soil in moderate latitudes and low altitudes and the catastrophic avalanches or "frane," with the special manifestations of soil flow in sub-polar regions. As Lozinski has shown, the rock streams in the Taunus quartzite and the "Felsenmeere" of the Odenwald should probably be referred to processes operating during the glacial period when conditions in Central Europe more resembled those of the sub-Arctic to-day.

From studies in Spitzbergen Sapper describes in some detail, and offers explanations for, the contrasted main types of *polygonal* or *Karreeboden* (which occur on flat areas and are unconnected with migrational movements of the soil) and the land migrations which occur on slopes due to the force of gravity acting upon the mass in cooperation with other forces. These contrasted structures which were first clearly differentiated by Nordenskiöld, Sapper proposes to distinguish as *Strukturboden* (Meinardus's term) and *Fliesserdeerscheinungen.* One may well differ with him as to the aptness of these distinctions, since the former term might properly be applied to the latter class of phenomena. "Polygonal ground" or "barrow ground" already in use is certainly preferable.

In connection with downward migration of the soil upon slopes, Sapper lays stress upon the favoring elements of absence of vegetation and presence of glaciers or snow masses to supply the saturating thaw water in regions of small rainfall. He dissents, however, from Nordenskiöld's view that the snow or ice is essential, citing their absence (at the time of his visit in late summer) in certain examples. To him we are indebted for some careful measurements of the dimensions of the structures and of the angles of slope in which they are found. He mentions the occurrence of small mud streams which display fluidal structure in concentric wrinkles parallel to their margins, also short streams one above the other, extending step fashion down the slopes. The reviewer would call attention to a further variation observed by him in Swedish Lapland, which the Swedish geologists report to be not uncommon. Local nucleii of soil movement on slopes produce circular platforms, a few feet in diameter in part within and partly without small niches in the slope, and in shape resembling nothing so much as the platforms for charcoal burning which are common on slopes of the Green Mountains of New England.

The "Thufa" which Spethmann described from Iceland, Sapper found in a few examples in Spitzbergen, which he described as "frost hillocks." In common with most other observers, Sapper sees in the processes which give rise to *Strukturboden* alternate freezing and thawing of the saturated ground, a belief which he has expressed in the term *Regelationsfliesserde.* Other names either quoted from others or suggested for the same structures are "flower beds" *(Blumenbeete),* "round beds" *(Rundbeete),* and "debris facets" *(Schuttfacetten),* as well as "little stone gardens" (*Steingärtchen*) long in use for similar structures found in the Alps. That the formation of these polygons in the soil is connected with a supersaturation with thaw water seemed clear from observations made near Advent Bay, where they are found below a snow drift. Here one sank deep in the mud, and the water circulated beneath the stone wreaths. A centrifugally directed pressure Sapper believes to exist within the polygons, because the clay in the centers contains more water than the more heterogeneous material outside. This inner cylinder of clay by freezing expands, expelling the marginal rocks toward the fissure and, as space becomes insufficient for the full dilatation, arches up at the center. With subsequent thawing the mass subsides, thus leaving the marginal rock rim in relief. The always frozen base of the structure plays the important rôle of retaining the thaw water within the surface layers of the ground.

The few illustrations are from photographs and are excellent, and the contributions together make a valuable addition to our knowledge of the subject. The subject is, however, a large one and the structures described are by no means all that have been observed. WILLIAM HERBERT HOBBS.